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Tuning Magnetic Properties through Coordination: From 2D Metal-Organic Networks to Metal Nanostructures

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X-ray magnetic circular dichroism (XMCD) spectroscopy is a powerful technique to examine magnetic nanostructures on surfaces. It gives element-specific, quantitative values of spin and orbital magnetic moments and their anisotropies. Using this technique we demonstrate the effect of local coordination on magnetic properties for very different systems, such as 2D metal-organic networks on surfaces, monolayer surface alloys, and quasifree metallic clusters on decoupling xenon matrices.

Metal-organic networks where single 3*d* metal atoms are forced into a 2D regular array by molecule spacers mark the limit of non-ferromagnetic systems where the magnetic properties of each magnetic center is driven by ligand field effects [1]. Lateral coordination with the molecular ligands yields unsaturated yet stable coordination bonds, which enable chemical modification of the electronic and magnetic properties of the 3*d* atoms independently from the substrate. The easy magnetization direction of the 3*d* center can be switched by oxygen adsorption, thus opening a way to control the magnetic anisotropy in supramolecular layers akin to that used in metallic thin films.

Bringing 3*d* transition metals in close proximity to heavy 4*d*/5*d* elements is another route to tune magnetic properties. The heavy elements introduce strong spin-orbit coupling effects to the systems under study, which—depending on the atomic coordination—can lead to exceptionally large magnetic anisotropies, e.g., in atomically thin $Fe_{50}Pt_{50}$ surface alloys grown on Pt(997) [2], but also to complex Dzyaloshinskii-Moriya driven magnetic phases. Furthermore, 4*d*/5*d* element systems on their own are of fundamental interest because of their borderline magnetic behavior in the smallest cluster size regime, where ferromagnetism is observed in the quasifree limit and orbital and spin moments are determined by finite size effects.

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